(including autogamy, endogamy, homogamy, preferential mating or "sexual selection" in Darwin's sense, and heterogamy); and on "genetic selection" or the inheritance of fertility. The last-named principle promises to be of special weight as a factor in evolution, though the proof of definite correlation of other physical characters with that of fertility must still be considered incomplete. The analysis of natural selection into autogeneric, heterogeneric and inorganic selection ("intra-selection" being ignored) is useful, and might have been carried still further.

A contribution to the theory of evolution so original and stimulating as Prof. Pearson's must necessarily run the gauntlet of much adverse criticism. This will probably take the form rather of objection to certain points of detail than to the general drift of his method. Certainly some passages and expressions seem capable of amendment. It is, for instance, scarcely allowable to speak of the approach of the coefficient of correlation to unity as "the transition of correlation into causation." As the author himself elsewhere points out, correlation does not imply causation, though the converse is no doubt true enough. The principle of recognition-marks in their widest sense seems again to deserve more consideration than it receives at his hands. They are requisite to ensure the actual effectiveness of the impulse towards preferential mating. It is worth notice in this connection that the author's view as to the species-forming tendency of differential fertility (which is distinct from "physiological selection," as understood by Romanes) is well exemplified by Dr. Jordan's work on "mechanical selection." In speaking of hybridisation with reference to atavism, the "Grammar" does less than justice to observed facts. The evidence afforded by crosses, such as those so carefully investigated by Standfuss at Zürich and by Prof. Cossar Ewart at Penicuik, has a bearing on heredity and atavism which cannot safely be ignored. Prof. Pearson contents himself with saying that in such cases, "from physiological and mechanical reasons, the gametes produce a zygote which does not give an individual blending the ancestry. Here any singularity almost may be expected." This statement, to say the least, seems wanting in precision. Again, a severe critic might allege that the author is apt to assume theoretical values (as in the case of the resemblance of first cousins) which have not stood the test of rigid proof.

We have not yet learned to like the new term "apolegamy," nor such a phrase as "a comparative few zygotes" (p. 453). The remarkable form of a sentence on p. 461 is probably due to a printer's error, as also the substitution of DAG for FAG at the bottom of p. 447. These, however, are small matters, and do not detract from the value of the book.

We must not be led into a discussion of the earlier chapters, a notice of which appeared in these columns at the time of their original publication. There is, however, one point on which we cannot refrain from joining issue. Prof. Pearson takes biologists to task for the loose way in which they often use such terms as "matter," "force" and "motion," as if no important questions lay behind them. Now it is certain that, in their employment of these expressions, biologists have no desire whatever to prejudice any philosophical problems. When metaphysicians and physicists are agreed about the definition of these terms, the biologist will doubtless be quite ready to follow suit. Meanwhile he must be allowed the use of ordinary language. But Prof. Pearson maintains that if these words are used in their everyday, or, as he calls it, their "figurative" sense, they ought to be defined. Why so? No definition is required for the particular end in view. Supposing an opponent were to say that the "matter" of the argument was not "attractive," and that there was no "force" in this or that contention, would the Professor waste time in making him define his terms? Can we not "beat about the bush" without entering into explanations that would satisfy the schoolmaster and the botanist? It would seem that here the Professor once more overshoots his mark.

It will be convenient to give, in conclusion, a summary of the main contention of these new chapters in the author's own words, as follows:—

"It is not absence of explanations, but rather of the quantitative testing of explanations, which hinders the development of the Darwinian theory." "The problem of the near future is not whether Darwinism is a reality, but what is quantitatively the rate at which it is working and has worked."

It is noteworthy to find him adding:—

"If that problem should be answered in a way that is not in accordance with the age of the earth, as fixed by certain physicists, it by no means follows that it is biology which will have to retrace its steps. When the rate is determined, it will be as exact in its nature as physical appreciations; and it will be a question of superior logic, and not of the superiority of the 'exact' over the 'descriptive' sciences which will have to settle any disagreement of biology and physics." . . . "It is a question of the *rate* of effective change, and when the biologists are in a position to make a definite draft on the bank of time, their credit will be just as substantial as that of the so-called exact sciences."

These last sentences, as coming from a mathematician, are highly significant; and we cannot but admire the courage that has given them expression. F. A. D.

HERTZ'S MECHANICS.

The Principles of Mechanics presented in a New Form. By Heinrich Hertz. Authorised English Translation, by D. E. Jones and J. T. Walley. Pp. xxviii + 276. (London: Macmillan and Co., Ltd., 1899.)

GREAT expectations were aroused by the publication, in 1894, of a book by Heinrich Hertz, with the title, "Die Principien der Mechanik in neuem Zusammenhange dargestellt." Perhaps it would set out the received theory of dynamics in strictly logical sequence; perhaps it would present a complete theory of energy independent of the notion of force; perhaps it would bridge the gap between the molecular and mechanical standpoints. Whether it would do any of these things or not, what Hertz might have to say would certainly be worthy of attention. Hertz died before the work was printed, and the task of seeing it through the Press was entrusted to Dr. P. Lenard. He tells us that the author had devoted the last three years of his life to the book, the last two being spent in perfecting its form; and, although there are indications that he was not even then

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completely satisfied, the work may fairly be regarded as the mature expression of his deliberate thought on the subject.

The book opens with a preface by Helmholtz, followed by the author's preface; then there is an introduction, and the author's theory is formulated in two books:—Book i.: Geometry and kinematics of material systems; Book ii.: Mechanics of material systems. Helmholtz's preface contains an account, which might be called an appreciation, of the scientific work of Hertz, and is further remarkable for the statement that, while Kelvin, Maxwell and Hertz appear to have derived fuller satisfaction from explanations of physical facts founded on some simple general conception, such as Hertz's "straightest path," he, for his part, had felt safer in adhering to the representation of physical facts and laws by systems of differential equations. In his own preface the author tells us that his object was "to fill up the existing gaps, and to give a complete and definite presentation of the laws of mechanics which shall be consistent with the state of our present knowledge, being neither too restricted nor too extensive in relation to the scope of this knowledge"; and that what he hoped was new in his work was "the arrangement and collocation of the whole—the logical or philosophical aspect of the matter."

In the introduction the author criticises the received theory of dynamics and the more modern doctrine of energetics, and proceeds to explain the character of the new theory which he proposes. The novelty consists in this: whereas the other two theories started from four fundamental concepts—space, time, mass and force, or energy—he requires only three—space, time and mass—and the hypothesis of concealed masses. In Book i. relations concerning spaces and times are considered, and we have a generalisation of ordinary kinematics, including definitions of the path and velocity of a material system, and its shortest and straightest paths. By a material system is meant what in the ordinary presentation of dynamics would be called a system of particles with invariable connections. Some of the definitions referred to contain arbitrary elements, but they are, at any rate, simple. The definition of *mass* might have been omitted with advantage. In Book ii. the author enunciates his "fundamental law"—that every free system moves in a straightest path. This law may be looked upon as an interpretation of the principle of least action for systems of which all the energy is kinetic, or as an extension of Gauss's principle of least constraint. He proceeds to show how the motions of systems which are not free can be brought under the fundamental law by means of the hypothesis of concealed masses—the visible system is regarded as linked on to another system by invariable connections—and it is proved that the equations of motion of the system contain terms which correspond to the "forces" of ordinary dynamics. It is, perhaps, not remarkable that the dynamics of distant gravitating bodies, which was the immediate object of the received theory, should offer special difficulties from the present point of view (§ 469); on the other hand, it is claimed that the new minimum principle is applicable to invariable connections of the type of pure rolling, in which the velocities are connected by non-integrable equations, and that it thus includes more phenomena than the principle of least action. A considerable portion of Book ii. is taken up with the consideration of cyclical systems. Hertz has here developed important conceptions due to Helmholtz. Throughout both books the "older synthetic method," that of a chain of propositions, has been adopted in order that the logical purity of the theory might be beyond dispute.

Whatever may be the influence exerted on the progress of mechanics by Hertz's kinematical generalisations and fundamental law, there cannot be any doubt of the value of his criticisms of existing dynamical theories. He has explained, in the clearest manner, the object of physical theories, and stated the conditions which such theories must satisfy. He has tested the received theory of dynamics—that which is associated with the names of Galilei, Newton, d'Alembert and Lagrange—in respect of logical permissibility, and in respect of appropriateness as an expression of facts. Concerning this representation of physical experience, he asks: "Is it perfectly distinct? Does it contain all the characteristics which our present knowledge enables us to distinguish in natural motions?" And his answer is "a decided—No." He has put his finger on the weakest part of the theory—the relation of the notion of internal stress to that of equal and opposite distance-actions. He makes the supposition that the theory can, even here, be rendered rigorous, and prefers to base his attack on the complexity of the various actions which the theory needs to assume. In a somewhat similar spirit he discusses the representation of physical facts by means of the theory of energy, although it is rather the logical permissibility than the appropriateness of this representation that is called in question.

The translators have done their work well on the whole. Here and there they have been too literal, or not literal enough; they have left some obvious misprints in the German text, and some in the translation, uncorrected; but these are slight blemishes, and we must be grateful to them for a rendering which admirably conveys the spirit of the original. Their translation should serve to make more widely known a book which certainly ought to be read by all who wish to have clear ideas concerning the most fundamental of the physical subjects. A. E. H. L.

ASSYRIAN AND BABYLONIAN ASTROLOGY.

The Reports of the Magicians and Astrologers of Nineveh and Babylon. By R. C. Thompson. Vol. i. Pp. xviii + 85 plates of cuneiform text. Vol. ii. Pp. xci + 148. (London: Luzac and Co., 1900.)

IT is now about thirty-five years ago since the late Edward Hincks, whose name will be honourably coupled with the history of cuneiform decipherment, astonished many folk by declaring that he had discovered in the British Museum tablets which related to the pseudo science of astrological astronomy. And it is not surprising that such a declaration evoked general interest, because reasonable grounds existed for hoping that when the texts on the tablets had been deciphered, some trustworthy information about Chaldean astronomy might be forthcoming. The labours of Hincks were followed by those of Lenormant and Oppert, but they had little

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